Advanced Generation: Reciprocating Gas Engines

Tech Brief

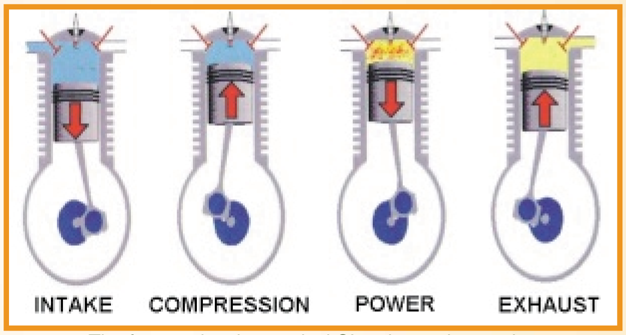
Distributed Energy Resources (DER) are a suite of onsite, grid-connected or stand-alone technology systems that can be integrated into residential, commercial, or institutional buildings and/or industrial facilities. These energy systems include distributed generation, renewable energy, and hybrid generation technologies; energy storage; thermally activated technologies that use recoverable heat for cooling, heating, or power; transmission and delivery mechanisms; control and communication technologies; and demand-side energy management tools. Such decentralized resources offer advantages over conventional grid electricity by offering end users a diversified fuel supply; higher power reliability, quality, and efficiency; lower emissions; and greater flexibility to respond to changing energy needs.

Reciprocating gas engines are the fastest-selling, least expensive distributed generation technology in the world today. Although most widely used in automobiles, reciprocating—or internal combustion (IC)—engines are also used to power devices such as air compressors, pumps, and electric generators for buildings.

Commercially available natural gas versions of the IC engine produce power from 0.5 kW to 10 MW, have efficiencies between 37 and 40 percent, and can operate down to NO_x levels of 1 gram per horsepower hour (hp-hr). When properly treated, these rugged engines can run on fuel generated by waste treatment (methane) and other bio-fuels. By using recuperators that capture and return waste exhaust heat, reciprocating engines also can be used in cooling, heating, and power (CHP) systems in buildings to achieve energy-efficiency levels approaching 80 percent.

Reciprocating gas engines offer many advantages over other technologies for small-scale power generation, including the ability to provide highly reliable, inexpensive backup power, provide power for remote locations, and generate onsite power during peak periods when utility charges are at their highest.

Reciprocating engines require fuel, air, compression, and a combustion source to function. Depending on the ignition source, they generally fall into two categories: spark-ignited (SI) engines, typically fueled by gasoline or natural gas; and compression-ignited (CI) engines, typically fueled by diesel oil.



The four strokes in a typical SI reciprocating engine

The four-stroke SI engine has an intake, compression, power, and exhaust cycle. In the intake stroke, as the piston moves downward in its cylinder, the intake valve opens and the upper portion of the cylinder fills with fuel and air. When the piston returns upward in the compression cycle, the spark plug fires, igniting the fuel/air mixture. This controlled combustion forces the piston down in the power stroke, turning the crankshaft and producing useful shaft power. Finally, the piston moves up again, exhausting the burnt fuel and air in the exhaust stroke. The CI engine operates in the same manner, except diesel fuel and air ignite when the piston compresses the mixture to a critical pressure. At this pressure, no spark or ignition system is needed since the mixture ignites spontaneously, providing the energy to push the piston down in the power stroke.

Market Potential

- Reciprocating engines have the largest share of the small power generation market and can be used in a variety of applications due to their small size, low unit costs, and useful thermal output.
- With fast start-up time, reciprocating gas engines can play integral back-up roles in many building energy systems.

Environmental Benefits

- Reciprocating engines have low greenhouse gas emissions when run on biofuels.
- Sophisticated exhaust gas treatment, such as selective catalytic reduction system, allows for emissions low enough to meet California and Texas emission standards.

Applications

With their wide power range and operating flexibility, reciprocating engines can be used for many purposes—local power grid and substation support, peak-shaving, remote power, CHP applications, high-density electric loads, standby power, and mechanical drive used for compressors and pumps—in industrial, commercial, institutional, and residential applications.

Program Goals and Activities

The goal of this program is to lead a national effort to design, develop, test, and demonstrate a new generation of reciprocating gas engines for DER applications that are cleaner, more affordable, reliable, and efficient than products that are commercially available today.

Performance targets for the next generation of reciprocating engines include:

- **High Efficiency** — The target for fuel-to-electricity conversion efficiency (low heating value) is 50 percent by 2010, a 30-percent increase from today's average efficiency.

- **Environment** — Engine improvements in efficiency, combustion strategy, and emissions reduction will substantially reduce overall emissions to the environment. The NO_x target for the gas reciprocating engine is 0.1g/hp-hr, a 95-percent decrease from today's NO_x emissions rate.

- **Fuel Flexibility** — Natural gas-fired engines are to be adaptable to future firing with dual fuel capabilities. Dual fuel options may be considered in the design.

Wakesha Reciprocating Engines

- **Cost of Power** — The target for energy costs, including operating and maintenance costs, is 10 percent less than current state-of-the-art engine systems while meeting new projected environmental requirements.

- **Availability, Reliability, and Maintainability** — The goal is to maintain levels equivalent to current state-of-the-art systems.

For further information:

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www.eren.doe.gov/power/

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www.eren.doe.gov/der/

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